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WATERTOWN ARSENAL
PRODUCTION DEPARTMENT

GUN DIVISION
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EVALUATION OF THE GERMAN CENTRIFUGAL CASTING PROCESS
FOR THE MANUFACTURE OF GUN TUBES

EPA 111

(Examination of Casting Produced with Dry Sand Mold Lining)

BY

John F. Wallace
Associate Metallurgist

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APPROVED:

J. L. Martin
Chief, Gun Division
Watertown Arsenal

14 WA-314/92, WA-WGD-15

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EVALUATION OF THE GERMAN CENTRIFUGAL CASTING PROCESS

FOR THE MANUFACTURE OF GUN TUBES

EPA 111

(Examination of Casting Produced with Dry Sand Mold Lining)

OBJECT

To investigate the effect of a dry sand mold lining on the cleanliness of a German 105mm centrifugally cast gun tube.

CONCLUSIONS

1. The dry sand lining remains in position near the mold wall and does not contaminate the body of the gun tube.
2. The sintered sand layer which adheres to the outside diameter of the tube can be completely and readily removed by taking a .200" cut in a lathe after the gun has been properly softened.
3. The use of a dry sand lining eliminates a source of moisture associated with ordinary mold washes.

John F. Wallace
Associate Metallurgist

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INTRODUCTION

The German Centrifugal Casting Industry employed three types of casting machines during World War II. The "Deutsche Eisenwerke", a watercooled horizontal machine, was the most recent development and was used to produce a majority of the 88mm and 105mm gun tubes.* New techniques were employed in the operation of this machine, including the spinning of a thin layer of dry sand onto the mold surface prior to the casting of the liquid metal. This sand layer (3 to 5mm in thickness) was substituted for the normal mold wash application. The dry sand, however, is not a source of moisture and it was claimed by German technicians that this sand would remain in place, held only by centrifugal force, and that it would not contaminate the body of the casting.

Additional advantages of this sand lining, claimed by the Germans, will be discussed in future reports on this project. A complete "Deutsche Eisenwerke" machine has been assembled at this Arsenal and its operation will be studied.

PROCEDURE

Two German 105mm howitzer tubes were shipped to this Arsenal from the European Theatre. They had been cast in a mold lined with a layer of dry sand as discussed above. Since the tubes were received in the "as cast" condition, they presented an opportunity to investigate the extent of sand penetration. Both exhibited a layer of sand sintered into the outside surface. It was found, however, that the "as cast" structure was too hard to be saw-cut. To facilitate sectioning, the guns were softened by a cycle anneal consisting of an austenitizing treatment at 1465° F. for eight hours, followed by a transformation treatment at 1300° F. for fifteen hours.

After softening, seven transverse discs were cut from one of the tubes and five discs from the other. Diagrams of the sectioning of these tubes are given at the end of the report. Disc #1, located 7" from the breech of the first tube, was selected for microscopic study since it was located near the pouring end of the mold. Maximum sand penetration into the body of the tube would be expected at this location because of the greater fluidity of the molten steel. A 1/2" thick radial strip was cut at twelve o'clock on this disc and photomicrographs taken of the sand layer, the boundary of this layer, and body of the casting. Finally, all discs were surface ground, macroetched, and photographed.

The longitudinal section between discs #1 and #1A, was centered in a Springfield 24" engine lathe and various types of cuts were taken to turn the sintered sand layer off the outside diameter. This investigation was conducted with the tool steel cutting tools, feeds, and speeds normally used in gun tube machining.

* Ordnance Target Report--C.I.O.S. -- "German Facilities for the Production of Centrifugally Cast Gun Tubes"--25 July 1945 -- Dr. J. L. Martin

RESULTS AND DISCUSSION

The various photomicrographs taken of the sand layer, metal body of the tube, and the boundary between the two are shown in Figures 1 and 2. The sintered sand layer is about .100" thick and composed of approximately one-half sand and one-half steel. The metal within the layer is decarburized and shows evidence of considerable grain boundary oxide penetration. The metal body of the tube has a spheroidized structure produced by the cycle annealing treatment. No evidence of sand contamination could be found near the sintered sand layer or further within the tube. The boundary of the two areas is so clearly defined that rapid solidification of the metal must have prevented the centrifugal force from driving the lighter sand into the body of the gun. The photomicrographs make it evident that the sand lining not only remains at the outside of the casting to protect the mold, but also that none of the particles contaminate the body of the centrifugal casting.

Figures 3 and 4 contain photographs of the macroetched discs from each of the gun tubes. The sand layer is present on the outside diameter of every disc but no evidence of sand contamination within the gun proper could be found. Discs #1 to #4 on the first 105mm tube have many cracks radiating from the bore. However, this condition is not present in the second 105mm tube. The cracks are believed to have been caused by cooling the casting at too rapid a rate after solidification and by the very high carbon content of this tube. (Analysis shows that the first 105mm tube contains 1.00% carbon and the second tube, .55% carbon.) No evidence of the presence of moisture in the lining was found in either the macro or micro specimens.

The extreme hardness of the "as cast" tubes necessitates a softening treatment before the tubes could be cut or machined. After softening, the sintered sand layer can be completely removed by normal gun turning methods if a .200" cut is made. This cut extends beneath and removes the sand without difficulty. A cut any less than .150" in depth may cause dulling of the tool by forcing the tip to cut within the sand layer.

FIGURE 1



SAND PENETRATION LAYER

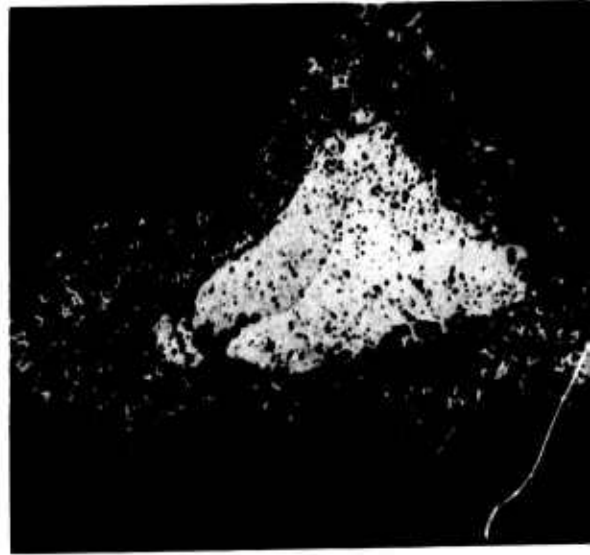
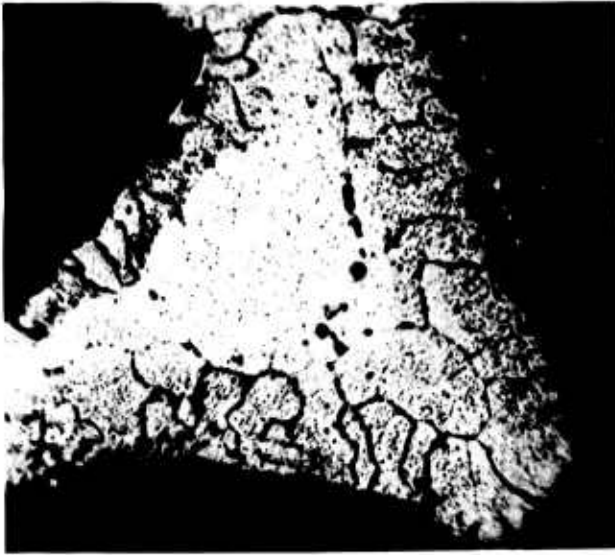
MAG. X100

METAL BODY OF CASTING

THE BOUNDARY BETWEEN THE SINTERED SAND LAYER AND THE METAL BODY OF THE CASTING IS CLEARLY DEFINED. THERE IS NO EVIDENCE OF SAND PENETRATION INTO THE BODY OF THE CASTING. THE DEPTH OF PENETRATION OF SAND LAYER IS ABOUT .100" DEEP.

WTN.639-8378

FIGURE 2



MAG. X1000

THE ABOVE PHOTOMICROGRAPHS SHOW THE STRUCTURE OF THE METAL WITHIN THE SINTERED SAND LAYER NEAR THE SURFACE OF THE CASTING. THIS METAL SHOWS EVIDENCE OF DECARBURIZATION AND GRAIN BOUNDARY OXIDE PENETRATION.



MAG. X1000

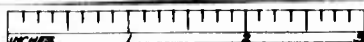
THE ABOVE PHOTOMICROGRAPH SHOWS THE STRUCTURE OF THE METAL WITHIN THE BODY OF THE CASTING. THE STRUCTURE IS SPHEROID CARBIDE PARTICLES IN A MATRIX OF FERRITE PRODUCED BY THE REQUIRED CYCLE ANNEAL FOR SOFTENING. THE PHOTOGRAPH WAS TAKEN NEAR THE BOUNDARY OF THE SAND PENETRATION LAYER AND SHOWS NO EVIDENCE OF SAND PARTICLES.



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WATERTOWN ARSENAL

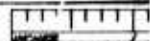
DISC #105-1-1 FROM 1ST 105MM CENTRIFUGALLY CAST GERMAN TUBE. DISC CUT 7" FROM BREECH.
TUBE IN ANNEALED CONDITION. CAST IN A HORIZONTAL WATER COOLED MACHINE. WTN.223-5338

DISC #105-
TUBE IN AN



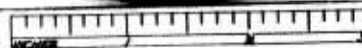
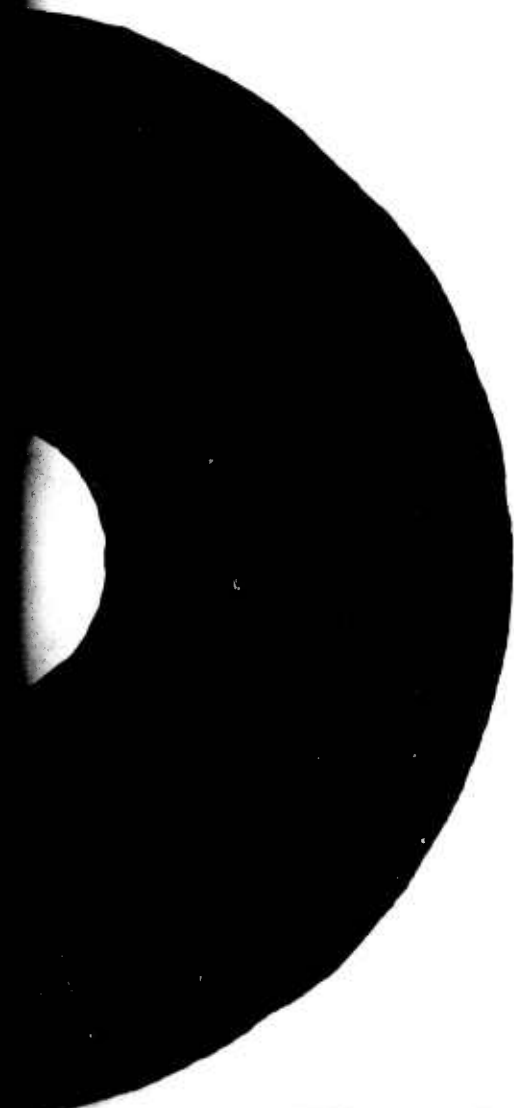
ORDNANCE DEPT. U.S.A.
WATERTOWN ARSENAL

5-1-2 FROM 1ST 105MM CENTRIFUGALLY CAST GERMAN TUBE, DISC CUT 26" FROM BREECH.
ANNEALED CONDITION. CAST IN A HORIZONTAL WATER COOLED MACHINE. WTN.223-5339

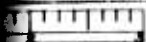


ORDNANCE
DEPT.

DISC #105-1-2 FROM 1ST 105MM CENTRIFUGAL
TUBE IN ANNEALED CONDITION. CAST IN A HORIZONTAL



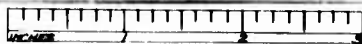
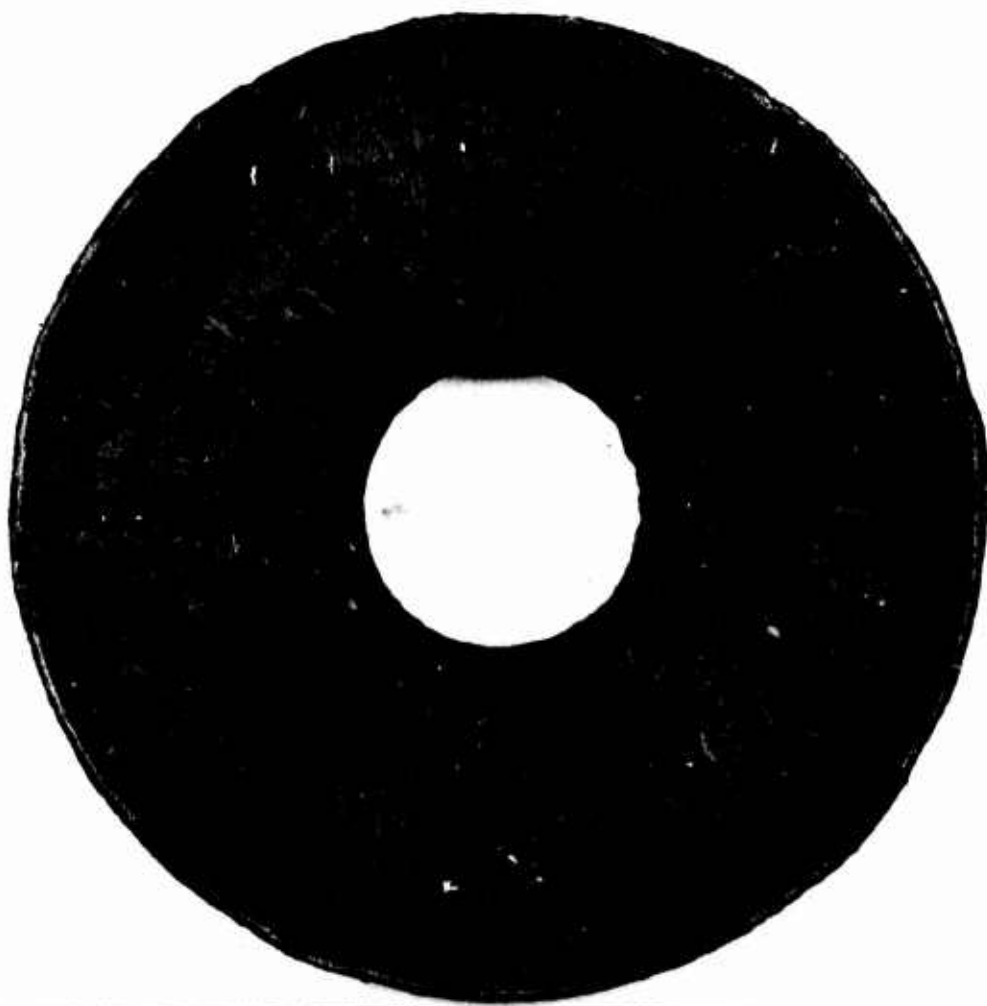
ORDNANCE DEPT. U.S.A.
WATERLOO, ARK.



U.S.A.

ST GERMAN TUBE. DISC CUT 45" FROM BREECH.
AL WATER COOLED MACHINE. WTN.223-5340

DISC #105-1-4 FROM 1ST 105MM CENTRIFUGALLY CAST GERMAN TUBE. DISC CUT 64" FROM BREECH.
TUBE IN ANNEALED CONDITION. CAST IN A HORIZONTAL WATER COOLED MACHINE. WTN.223-5



ORDINANCE DEPT. U.S.A.
WATERTOWN ARSENAL

DISC #103-1-5 FROM 1ST 105MM CENTRIFUGALLY CAST GERMAN TUBE. DISC CUT 83" FROM BREECH.
TUBE IN ANNEALED CONDITION. CAST IN A HORIZONTAL WATER COOLED MACHINE. WTN.223-5342

DISC #105-1-6 FROM 1ST 105MM C
TUBE IN ANNEALED CONDITION. CA



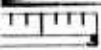
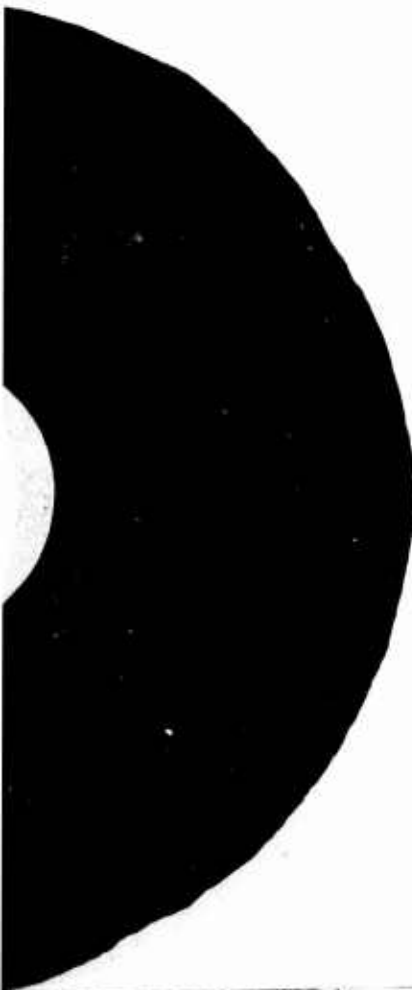
ORDNANCE DEPT. U.S.A.
WATERLOO, ARSENAL

#105-1-6 FROM 1ST 105MM CENTRIFUGALLY CAST GERMAN TUBE. DISC CUT 102" FROM BREECH.
IN ANNEALED CONDITION. CAST IN A HORIZONTAL WATER COOLED MACHINE. WTN.223-5343



DISC #105-1-7 FROM 1ST 105MM CENTRIFUGALLY CAST GERMAN TUBE IN ANNEALED CONDITION. CAST

FIGURE 3

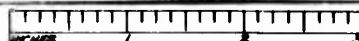


GERMAN TUBE. DISC CUT 102" FROM BREECH.
WATER COOLED MACHINE. WTN, 223-5343



ORDINANCE DEPT. U.S.A.
WATER TOWN ASSEMBLY

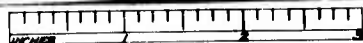
DISC #105-1-7 FROM 1ST 105MM CENTRIFUGALLY CAST GERMAN TUBE. DISC CUT 121" FROM
TUBE IN ANNEALED CONDITION. CAST IN A HORIZONTAL WATER COOLED MACHINE. WTN



ORDNANCE DEPT. U.S.A.
WATERLOO ARSENAL

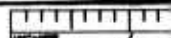
DISC #1C5-2-1 FROM 2ND 105MM CENTRIFUGALLY CAST GERMAN TUBE. DISC CUT 4" FROM BREECH.
TUBE IN ANNEALED CONDITION. CAST IN A HORIZONTAL WATER COOLED MACHINE. WTN.223-5333

DISC #1
TUBE IN



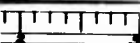
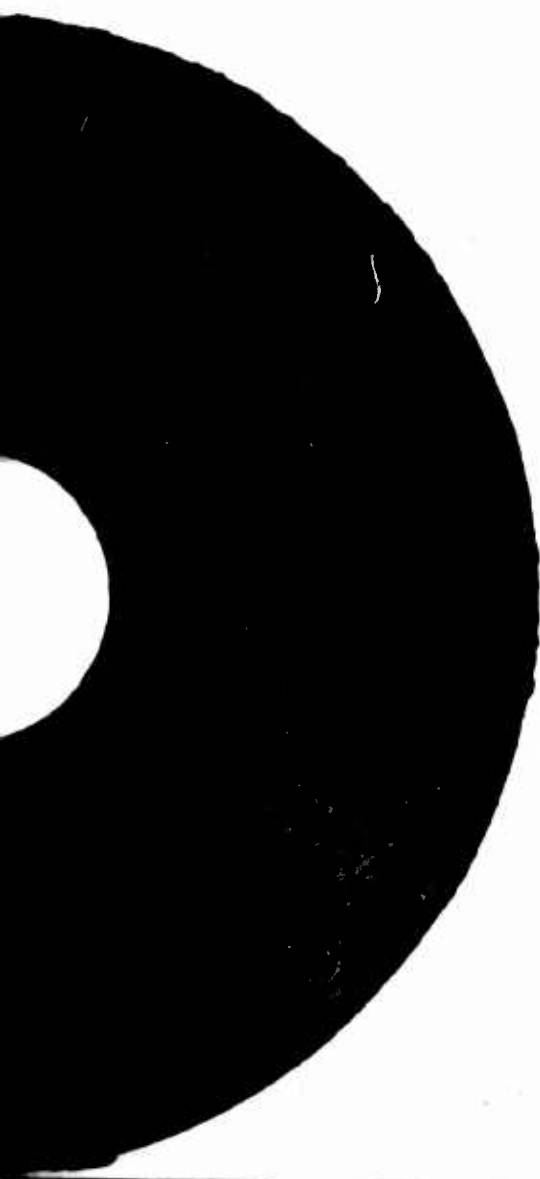
ORDNANCE DEPT. U.S.A.
WATERTOWN ARSENAL

A FROM 2ND 105MM CENTRIFUGALLY CAST GERMAN TUBE. DISC CUT 23" FROM BREECH.
LED CONDITION. CAST IN A HORIZONTAL WATER COOLED MACHINE. WTN.223-5334



ORDNANCE
WATERTOWN ARSENAL

DISC #105-2-2 FROM 2ND 105MM CENTRIFUGAL
TUBE IN ANNEALED CONDITION. CAST IN A HO



USA
W.N.

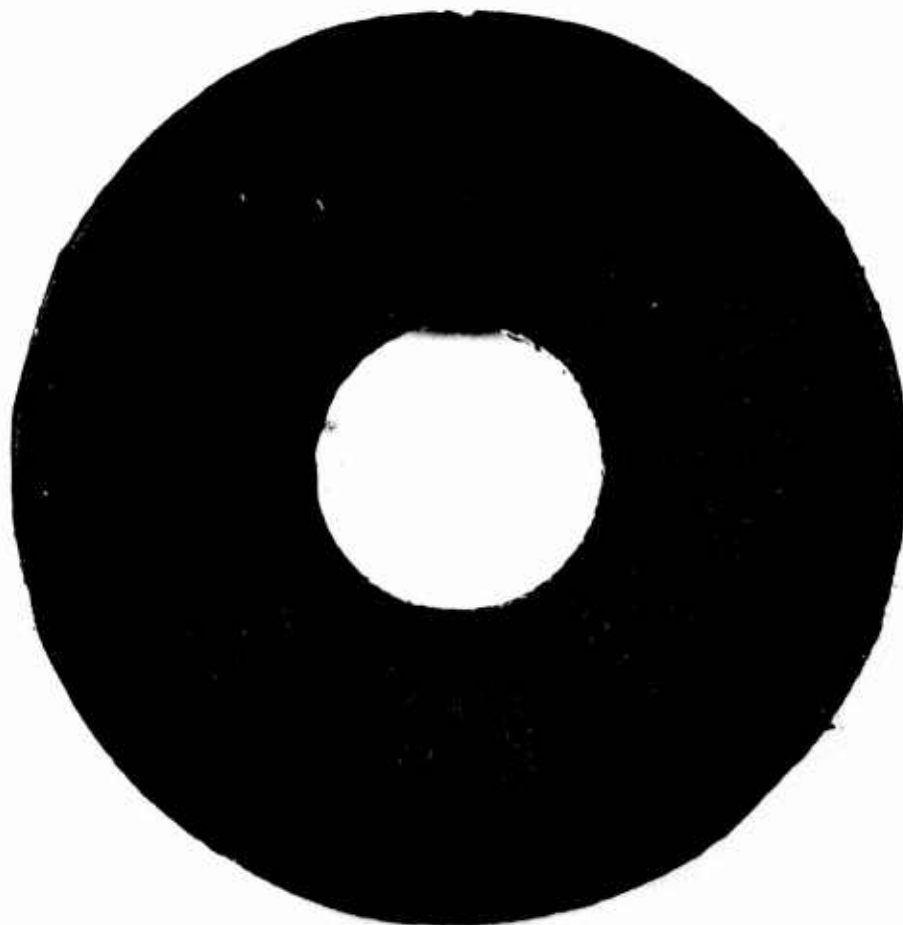
ST GERMAN TUBE. DISC CUT 40" FROM BREECH.
TAL WATER COOLED MACHINE. WTN.223-5335



ORDNANCE DEPT. U.S.A.
WATER TIGHT ARMORY

DISC #105-2-3 FROM 2ND 105MM CENTRIFUGALLY CAST GERMAN TUBE. DISC CUT 76" FROM
TUBE IN ANNEALED CONDITION. CAST IN A HORIZONTAL WATER COOLED MACHINE.

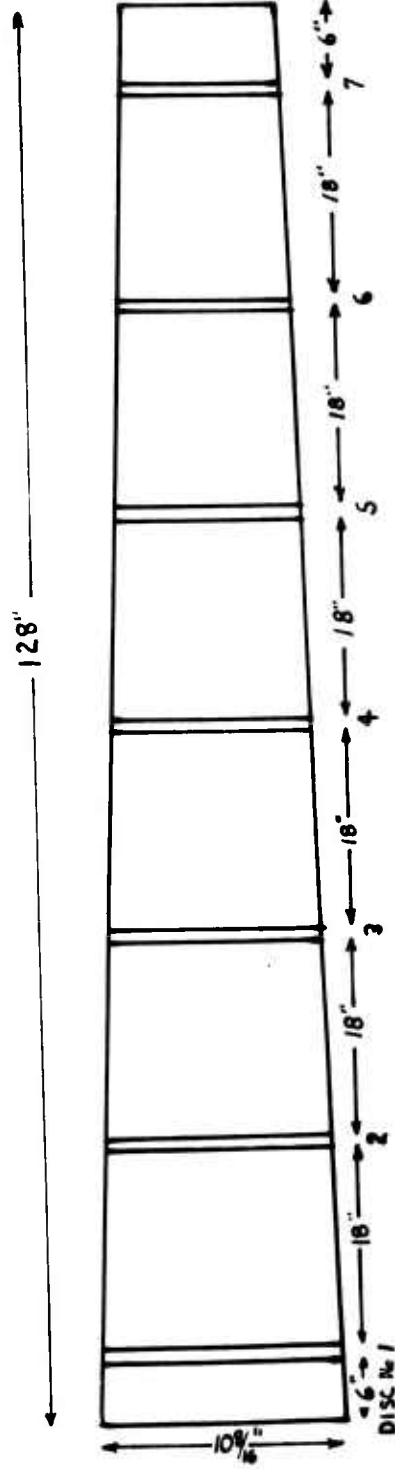
FIGURE 4



DISC #105-2-4 FROM 2ND 105MM CENTRIFUGALLY CAST GERMAN TUBE, DISC CUT 112" FROM BREECH.
TUBE IN ANNEALED CONDITION, CAST IN A HORIZONTAL WATER COOLED MACHINE. WTN.223-5337

DISC CUT 76" FROM BREECH.
MACHINE. WTN.223-5336

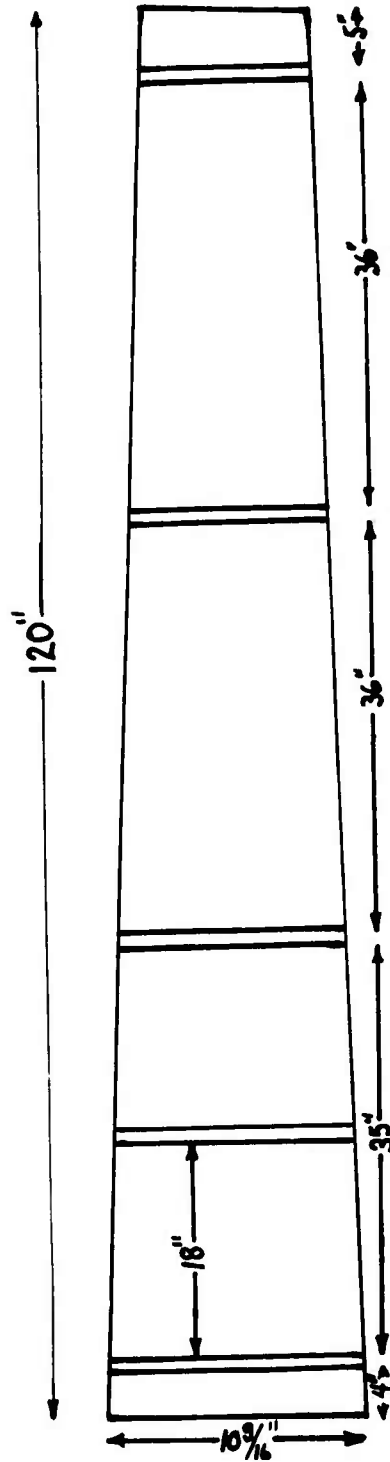
FIRST TUBE



ALL DISCS ARE $\frac{3}{4}$ " THICK

SECTIONING OF GERMAN CENTRIFUGALLY
CAST 105MM TUBE

SECOND TUBE



ALL DISCS ARE 3/4" THICK

SECTIONING of GERMAN CENTRIFUGALLY
CAST 105MM TUBE